

SECTION 159010 – DIRECT DIGITAL CONTROL / UTILITY CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. This section applies to all Utility Control System instrumentation. Product quality, installation, and operation shall meet the requirements specified herein unless indicated otherwise on the design drawing(s).
- B. The existing UCS architecture consists of a single Ethernet LAN supporting dual servers, operator workstations, printers and Ethernet to MS/TP data routers supporting multiple MS/TP LANs. The MS/TP networks include over 200 point-to-point modems and data converters used to extend each MS/TP LAN segment. Operator workstations are Windows 98/2000 based systems running Dorsett's Infoscane 2000, Oracle 8.0 Client, and other custom applications. Servers are Windows Server 2003 based systems running Dorsett's Infoscane 2000 and Oracle 9 Database Manager. The UCS monitors and/or controls approximately 3.5 million square feet of conditioned space in excess of 100 buildings, comprising more than 15,000 connected field devices. Due to MSFC's multi-million dollar investment in the large installed UCS product base and to ensure 100% compatibility with the existing hardware and software, all construction, renovation or modification of facilities shall be an extension of the existing UCS architecture. For all modifications and/or additions that include UCS or affect UCS, the design of the UCS control system network and UCS equipment is done by a specialized in-house UCS design group at MSFC.

1.2 PRE-CONSTRUCTION MEETING

- A. A control system pre-construction meeting shall be held prior to undertaking any control system construction installations at MSFC. The contractor's construction supervisor or field manager must attend this meeting. The following individuals shall attend this meeting:
 - 1. PROJECT ENGINEER
 - 2. CONSTRUCTION INSPECTOR
 - 3. UTILITY CONTROL SYSTEM REPRESENTATIVE
 - 4. UTILITY CONTROL SYSTEM DESIGNER
 - 5. CONTRACTOR CONSTRUCTION SUPERVISOR
- B. The purpose of the meeting is to review this specification and discuss the project prior to starting work. Proper construction techniques and expected results will be discussed. In general this meeting will address questions, or concerns, by any party, so that a clear understanding of the job scope and contractor responsibility is understood.

1.3 QUALITY ASSURANCE

- A. The instrumentation installation shall be under the direct supervision of individuals with a minimum of 5 years experience in the installation and service of similar instrumentation. The

contractor shall submit a list of projects, dates, and control descriptions as proof of experience installing similar instrumentation.

1.4 GENERAL REQUIREMENTS

- A. Section 16050 "Basic Electrical Materials and Methods," applies to work specified in this section.
- B. Section 15900 "HVAC Instrumentation and Controls", for non-DDC control system instrumentation.

1.5 SYSTEM DESCRIPTION

- A. A control system consists of: sensors, indicators, final control elements, interface equipment, other apparatus, accessories, and software, connected to distributed controllers operating in a multi-user, multitasking environment on Local Area Network(s) and programmed to control mechanical systems.

1.6 SUBMITTALS

- A. If required by the Schedule of Submittals, prior to beginning work provide the following submittals in accordance with Section 01330, "Submittals." Submittals shall be provided in sufficient detail to show full compliance with the specification.
- B. Product Data
 - 1. Data composed of catalog cuts, specifications, product data, warranty information and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. A technical submittal must be submitted including specification compliance, technical sheets, and factory representative authorization. The technical submittal shall contain the following:
 - a. Specification Compliance: The compliance document shall address each paragraph of the specification by indicating COMPLY, EXCEED, or EXCEPTION. Do not indicate COMPLY unless the proposed system exactly meets the paragraph requirement. If EXCEED or EXCEPTION is indicated, then provide a clear and concise explanation of the variance from the specifications and the net effect this would have on the proposed system.
 - b. Technical Sheets: Provide technical sheets on all system components shown on the design drawing(s).
- C. Shop Drawings
 - 1. The Contractor shall submit complete schematic drawings of the entire control system to the Government for approval before work begins.
 - 2. Submittals shall graphically show layout and connection of components and include schematic diagrams of systems. Samples of such systems, not all inclusive, shall consist of air handling systems, chilled water, steam, and hot water systems. Communication trunk diagrams shall designate and identify the specific building location of each

application-specific or multi-function controller card and the relative position of each card on respective trunks.

3. The Contractor shall provide detailed I/O point summaries indicating each instrumentation point with wire termination identifications for each point and grouped by individual I/O card.
4. The control schematics shall indicate the differential pressure setpoints for all air filters.
5. Four (4) copies of the following as-builts shall be provided in hardcopy and on compact disc (CD) in either Intergraph Microstation or DXF format and shall include Contractor's original, un-translated drawing file.
 - a. Wiring diagrams
 - b. System schematics
 - c. Communication trunk layout
 - d. Sequence of Operation

D. Test Reports

1. Thirty days prior to the start of system verification, three (3) copies of written test plans describing control system verification and operational functionality procedures shall be submitted for Government approval. The Contractor is responsible for the development of the test plans. Test plans shall validate the intended purpose and operational effectiveness of the entire system; this includes all hardware devices and software sequences called for on the design drawings.
2. Control system verification procedures describing how the operation of each control loop will be verified shall be submitted by control loop, identifying each sensor, actuator, controller, transducer, and measuring device, as required. The procedures shall describe adjustments in terms of control component positions, input and output signals and ranges, air and water flow rates, temperature and humidity setpoints, and other pertinent control parameters. The contractor shall provide trending charts to verify that all equipment/systems are controlling properly.
3. Control system verification test reports describing test results of each control loop shall be submitted in bound form and shall indicate the final values and settings of each control component in each control loop. Where testing indicates a necessary deviation from the contract drawing sequences of operation and controls submittals, the Government shall be informed immediately. Any deviations shall be made only after Government approval and the test report shall note any changes in the control loop or component settings caused by the deviation. One (1) hardcopy and two (2) electronic copies on CD of the control system verification test report shall be submitted within 30 days after completion of testing.

- E. Manufacturer's Instructions: Contractor shall submit three (3) hardcopies and three (3) electronic copies on CD of manufacturer's instructions describing installation of a product or system, special notices and material safety data sheets concerning impediment, hazards, safety precautions, startup, shutdown, and emergency operation.

- F. Operation and Maintenance Manuals: Operation and maintenance manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions. Contractor shall submit three (3) hardcopies and three (3) electronic copies on CD of O&M documentation. Operation and maintenance manuals shall be provided for all control system instrumentation products.

1.7 TELECOMMUNICATIONS

- A. Telecommunication lines are furnished by the Government. If installation of a communication line to a new field interface device is specified on the design drawing(s), the Contractor shall submit a written request to the COTR 30 days prior to system startup. The Contractor shall furnish the modems specified below for installation by the Government as required on contract drawings.
1. Modems are available from:
 - a. Black Box Corporation (877) 877-2269
 - b. Patton Electronics Co. (301) 975-1000
 2. Company websites:
 - a. <http://www.blackbox>
 - b. <http://www.patton.com>
 3. One (1) rack-mount modem:
 - a. Black Box Corp. P/N ME758C-RJ11
 - b. Patton Electronics P/N 1080ARC
 4. One (1) stand-alone modem:
 - a. Black Box Corp. P/N ME475A
 - b. Patton Electronics P/N 1080

PART 2 - PRODUCTS

- A. The Controls Contractor shall furnish components required by design and described herein.

2.1 DIRECT DIGITAL CONTROL (DDC) EQUIPMENT

- A. Utility Control System (UCS): This work includes all material, equipment, and appurtenant accessories necessary for, or incidental to, the installation of a complete Direct Digital Control (DDC) System as specified in the design package. The appropriately selected DDC configuration shall be capable of controlling processes in the building through configurable electronic controller boards. This configurable hardware shall be electronically interfaced via an Interface Card (CPU), manufactured by Dorsett's Inc., <http://www.dorsetts-inc.com/>, through telecommunication data lines to the central computer-based Utility Control System (UCS) located in Room 29 of Building 4250. Complete operational compatibility shall be maintained between the central UCS Infoscan system, both hardware and software, as manufactured by Dorsett's Inc. and the direct digital controllers. The central host computer communicates via Government-furnished telecommunication lines and contractor installed modems to Dorsett's Interface Panel(s) located in the building(s) where the project is being performed. The Interface Panel communicates with application-specific controllers or multi-function controller cards, which implement direct control of equipment through industry standard electronic signals.
- B. The term compatible means that the DDC hardware and software will communicate directly with the central host Infoscan application and that all existing UCS programs will function completely to control and monitor related equipment. It also means that engineering units, values, or parameters utilized within the panels or controllers are compatible with units used within the Infoscan System. The field hardware and the central host computer shall communicate and be fully programmable from the host Infoscan application.

- C. Operators shall have the ability to specify within the host database and in standard engineering units the amount by which the point must change at the sensor before it is reported as changed to the central host computer in Building 4250. This feature provides a system function referred to as "report-by-exception." Interface cards only report to the central computer point value changes that exceed the selected delta value. This minimizes data traffic on telecommunication lines to and from the central host computer.
- D. Each point that is used within the process shall be displayable and accessible through an Infoscan point review. When these points are represented as displayed values on host computer graphic displays, operators shall be able to select these values with a point device and retrieve accurate data within 20 seconds.
- E. Computer graphic displays shall be developed to represent each HVAC or environmental control component or system. These pictorial displays shall represent a chiller with all support pumps, valves, towers, air handlers, etc. All related analog and status points shall be dynamically represented on the display. If an analog or binary point changes value beyond the delta limit, this condition must be reported to an operator workstation within 20 seconds.
- F. The Contractor shall perform all application programming and point configurations through existing operator workstations via Infoscan software. All programming and graphic display generation for a completely operational system shall be provided.
- G. Field Interface Device: A Field Interface Device, also called FID, SID, MID, JID, etc., is a solid state electronic device with supporting software that provides an interface and permits communication between field controllers and the UCS host. This device is the Dorsett's CPU card into which the multi-function or application-specific cards are interfaced. It is connected via Government-furnished telecommunication lines to the UCS central computer in Building 4250. It has hardware and software compatibility with the existing Utility Control system. This card functions on a "report-by-exception" basis as described earlier in this section. If a new Interface Device is required, it shall be acquired from Dorsett's, Inc.
- H. Microscan Multiplex Panel (MUX):
 - 1. A MUX is a completely configured field panel consisting of Microscan multi-function card(s), power supply(s), terminal strips, and fully contained within a UL listed, NEMA rated enclosure. It is available in either a one, three, or six card version and is manufactured by Dorsett's, Inc.
 - 2. All Microscan Multiplex Panel (MUX) enclosures shall have a trough wire-way mounted below the enclosure for conduits to enter or exit. Chase nipples or conduits, 2 inches minimum diameter, 6 inches maximum length, shall be used to connect the trough to the bottom of the control panel enclosure. Only penetrations in the bottom of enclosures shall be made unless otherwise specified on contract drawings.
- I. Multi-Function Controller Card: A multi-function controller card is a solid-state electronic control board with generic input-output channels. All configuration parameters are fully programmable via the UCS central host computer. The controller card is manufactured by Dorsett's, Inc. and is commonly called a Microscan card.
- J. Application-Specific Controller: An application-specific controller is a solid-state electronic assembly designed to control the functions of a specific type of electrical or mechanical

equipment. These programmable cards shall be connected and communicate to the UCS system through the Field Interface Device.

- K. Equipment Specific Controller (ESC): An equipment specific controller is any controller that is user programmable such as programmable logic controllers (PLC), PID controllers, etc. An ESC, when allowed by contract drawings and specifications, shall have all pertinent accessories included for the programming, downloading, and documentation of software. Where front panel programming of the ESC is not readily available, the contractor shall provide a Government approved programming device including software, cables, hardware locks, etc. to provide for the physical connection to the ESC and access to the non-volatile memory for programming of the ESC. Programming software shall be provided on factory media with all/any serial numbers, key codes, etc. such that the media can be registered with the manufacturer. For all ESC's, the contractor shall provide two (2) hardcopies of the factory programmed software logic. Owner's manual and programming manual shall also be included with all ESC installations.

2.2 FIELD DEVICES

A. General:

1. **The use of interface signal converters is not allowed unless otherwise indicated on design drawings.**
2. 24 volt AC power sources shall be 120 volt AC primary input, 4 amp minimum rated secondary, on/off switch, circuit breaker mounted in metal enclosure.
3. Uninterruptible Power Sources (UPS) shall have hot-swappable batteries, buck-boost automatic voltage regulation and 15 minutes minimum uptime.

- B. Temperature Sensor: Temperature sensors shall be 100 Ohm or 1000 Ohm 0.00385 coefficient platinum Resistive Temperature Devices (RTD) with a transmitter. Temperature sensors shall conform to DIN-IEC-751 class B (+/- 0.12%). As minimum requirements, the repeatability shall be +/- 0.1 degrees C and the stability shall be less than +/- 0.1 degree C drift per year. The transmitter shall be 4-20 mA loop powered having a calibration accuracy of +/- .1% of span and a linearity of 0.1% of span.

1. Duct Temperature Sensor: Probe sensors for supply air and return air shall have averaging elements and extend two-thirds of the duct width as a minimum. Probe sensors for mixed air shall have bendable averaging elements with a minimum length equivalent to five times duct width. Non-platinum 0.00385 coefficient RTD's having platinum equivalent accuracy may be used.
2. Room Temperature Sensor: Room sensors shall be provided with a high impact plastic cover and may include an access port through which a hand-held or laptop device can be connected for communicating with the application-specific controller.
3. Immersion Well Temperature Sensor: Immersion sensors with thermowells shall be installed in liquid and steam applications. Thermowells shall be stainless steel.

C. Pressure Sensor

1. Static Air Pressure Sensor: Pressure sensors shall be 4 to 20 milliamp, loop powered, 1/8-inch brass barb fittings and 1% full-scale accuracy. Static pressure sensors shall have

a range approximately twice the setpoint called for in the sequence of operation. Duct static pressure sensors must be located downstream of fan 2/3 of the duct length.

2. Liquid and Gas Pressure Sensor: Pressure sensors shall be Kele and Associates Model 360C. A pigtail siphon shall be installed in steam applications. Isolation valves shall be installed on each device port to facilitate removal/replacement. <http://www.kele.com>
3. Low Differential Air Pressure Sensor: Pressure sensor shall be Setra Model 265. <http://www.setra.com/>

D. Humidity Sensor

1. Relative Humidity Sensor: Humidity sensors shall be solid-state with plus or minus 3 percent minimum accuracy. Sensor output signal shall be loop powered 4 to 20 milliamps.

E. Pressure Switch

1. Air Differential Pressure Switch: Differential pressure switches for airflow confirmation shall be Dwyer Instruments Model 1910 series. <http://www.dwyer-inst.com>
2. Liquid Differential Pressure Switch: Differential pressure switches for proving water flow shall be Penn Model P74FA-5. Isolation valves shall be installed on each device port to facilitate removal/replacement.

- F. Pneumatic Transducer: Pneumatic transducers shall be 4 to 20 milliamp input, minimum supply pressure shall be 25 PSI, control range shall be 3 to 15 PSI, air connection shall be 1/8 inch brass barb or 1/8 inch FNPT and utilize electronic feedback pressure control. Branch line shall have a 0 to 30 PSI maximum range pressure gauge installed.

- G. Actuators: Electronic actuators shall be operated by industry standard process signals.

- H. Enclosures: Enclosures shall be UL listed, constructed of minimum 14 gage sheet metal with spot welded joints, gray enamel finish and suitable for the application. Doors shall have a full-length left-hand piano hinge and coin/screwdriver operated latch.

- I. Utilities Metering: All programmable utility meters as required on contract drawings shall have all pertinent accessories included for the programming, downloading, and documentation of software. Where front panel programming of the meters is not readily available, the contractor shall provide a Government approved programming device including software, cables, hardware locks, etc. to provide for the physical connection to the meter and access to the non-volatile memory for programming of the meter. For all programmable meters, the contractor shall provide two (2) hardcopies of the factory programmed software logic. Owner's manual and programming manual shall also be included with all installations.

Meter output(s) shall be directly connected to the Utility Control System DDC hardware. Meter electrical ratings shall be compatible with the Utility Control System DDC hardware. Pulse outputs shall indicate an accumulated quantity. Minimum pulse output duration shall be 0.25 seconds. Pulse output type shall be open-collector/current sinking or form C relay contacts. If specified on the contract drawings, the following utility meter to UCS connections may be required:

1. Pulse output meters:
 - a. Condensate

- b. Industrial water
 - c. Potable water
 - d. Natural and Propane gas
 - e. Process make-up water
 - 2. Analog output rate meters:
 - a. Chilled water flow
 - b. Hot water flow
 - c. Process flow
 - 3. Pulse and Analog output meters:
 - a. Electrical power
 - b. Steam
 - c. BTU
- J. Voltage/Phase-loss monitor: Device shall be selected per application; automatic reset type with DPDT form C relay outputs, adjustable trip setpoint.
- K. Refrigerant/HCFC Monitor: Device shall have, at a minimum; scalable 4 to 20mA analog output indicating refrigerant levels in Parts-Per-Million (PPM) and programmable SPDT alarm relay.
- L. Indoor Air Quality (IAQ): Device shall have an analog 4 – 20mA output corresponding to Carbon Dioxide (CO₂) concentrations ranging from 0 to 2000 ppm.
- M. Gas Detection: Gas detection devices, i.e. Oxygen Deficiency, Hydrogen, Fluorine and Carbon Monoxide shall have form C relay alarm output(s).
- N. Current Switch: Device shall be capable of switching 150mA continuously. Split core design with adjustable trip point and capable of switching AC or DC circuits. Applicable for VFD applications down to 6Hz and powered by monitored line.
- O. Water Level Detection: Device shall have form C relay alarm output(s).
- P. Moisture Leak Detection: Device shall provide the following features:
- 1. By-zone form C relay interface capable of 32 alarm outputs
 - 2. ALARM, FAULT, and HORN form C relay outputs
 - 3. 36 hour battery backup
 - 4. Capable of monitoring 32 independent zones
 - 5. Provides subsequent alarming, no matter how many zones go into ALARM or FAULT
 - 6. Identifies location, time & date of all ALARM and FAULT conditions displayed in chronological order via a LCD alphanumeric display
 - 7. ALARM, FAULT and POWER front-panel mounted LED indicators
 - 8. Lineal leak detection tape
- Q. Variable Frequency Drive: VFD shall have an analog 4 – 20mA input for speed control and a contact-closure input for start/stop control.

2.3 LABELING

- A. Sensor and Control Devices: Each sensor and each control device shall be labeled at the sensor or device with the Infoscan database point name that identifies it. The point name shall be displayed in print achieved electronically or typographically on Mylar adhesive labels. Minimum label size shall be 2 inches by 7/8 inches. Label color shall be silver background with blue border. Printed text shall be black.
- B. Enclosures: Field Interface Device and Microscan Multiplex panels, as a minimum, shall be labeled. Labels shall be engraved plastic, beveled edges, black background, white letters. Letter height shall be 1/2 inches minimum. Overall label dimensions shall be 1.25 inches minimum height, length as required. Labels shall be centered along width and located within upper 1/4 area of enclosure door. Minimum distance from top of enclosure shall be 3 inches. Labels shall be affixed with adhesive cement. Field Interface Device and Microscan Multiplex panels shall be labeled consistent with design drawing terminology.
- C. Terminations: Each terminated wire shall be clearly labeled with Field Device Infoscan point name (example 4200-AH1-SAF) at the Field Device and at each wire termination. Labeling shall be heat-shrink-type and device or point names shall be displayed in print achieved electronically or typographically. The Government shall approve labeling medium and method before work begins. One source for white non heat-shrinkable plastic sleeves with print-type capability is: Brady Corporation, 800-537-8791, Brady P/N: WMS-117-319, <http://www.bradyid.com>.

2.4 WIRING

- A. Power and Control Wiring: All wiring shall be installed in EMT conduit except that plenum-rated wire may be used in low voltage runs in concealed but accessible ceiling areas and computer room sub-floor only. A.C. power wiring shall not be installed in the same conduit, or pathway, with low voltage (24 volt or less) signal wiring. All low voltage UCS control wiring shall be installed in dedicated conduit. Flexible conduit shall not exceed 3 feet. Conduit shall be 3/4 inches minimum diameter. Wiring specifications are as follows:
 - 1. 1-Pair, 22 AWG, stranded (7X30), tinned copper conductors, polypropylene insulation, maximum O.D. of 0.15 inches, aluminum foil-polyester tape 100% shield, 24 AWG stranded (7X32) tinned copper drain wire, and PVC jacket. Belden Part #1266A or equal.
 - 2. 2-Pair, 22 AWG, stranded (7X30), tinned copper conductors, polypropylene insulation, maximum O.D. of 0.17 inches, individual aluminum foil-polyester tape shielded pairs, 100% shield coverage, 24 AWG stranded (7X32) tinned copper drain wire, and PVC jacket. Belden Part #8723 or equal.
 - 3. 1-Pair, Plenum-rated, 22 AWG, stranded (7X30), tinned copper conductors, Fluorinated Ethylene Propylene (FEP) insulation and jacket, maximum O.D. of 0.12 inches, aluminum foil-polyester tape 100% shield, 22 AWG stranded tinned copper drain wire. Belden Part #88761 or equal.
 - 4. 2-Pair, Plenum-rated, twisted pairs, 22 AWG, stranded (7X30), tinned copper conductors, Fluorinated Ethylene Propylene (FEP) insulation and jacket, maximum O.D. of 0.15 inches, individual aluminum foil-polyester tape shielded pairs, 100% shield coverage, 24 AWG stranded (7X32) tinned copper drain wire. Belden Part #88723 or equal.
- B. Wires connecting field devices shall not be spliced or butted together. They shall be "home runs" from the field device to the panel. A power disconnect switch shall be provided at each

electronic card used in the control system. This includes controller cards used on air handlers, VAV's, etc.

- C. MUX panel control wiring shall have shield/drain wires terminated at a grounding bar in the wire trough located beneath the MUX panel.

PART 3 - INFOSCAN INTERFACING

- A. Equipment described in this section shall interface to the existing InfoScan system using standard interface protocols as shown on contract drawings. Typical industry standard interfaces are Johnson N2, Modbus, BACnet, DALI, & HART.

- B. The following categories list the minimum required interface protocol read/write properties:

1. Chiller Requirements (dependant upon chiller type)
 - a. Read Properties:
 - 1) Chiller run status
 - 2) Evaporator leaving water temperature
 - 3) Evaporator entering water temperature
 - 4) Condenser leaving water temperature
 - 5) Condenser entering water temperature
 - 6) Condenser refrigerant pressure
 - 7) Evaporator refrigerant pressure
 - 8) Motor winding temperature
 - 9) Bearing oil temperature
 - 10) Oil temperature
 - 11) Oil pressure
 - 12) Compressor % RLA.
 - b. Write Properties:
 - 1) Chiller enable
 - 2) Chiller disable
 - 3) Evaporator leaving water temperature setpoint
 - 4) Percent load setpoint
2. Steam Boiler Requirements
 - a. Read Properties:
 - 1) Boiler Run Status
 - 2) Low water
 - 3) High water
 - 4) Boiler Alarm
 - 5) Stack Temperature (fuel-fired only)
 - b. Write Properties:
 - 1) Boiler Enable
 - 2) Boiler Disable
 - 3) Steam Pressure Setpoint
3. Hot Water Boiler Requirements

- a. Read Properties:
 - 1) Boiler Run Status
 - 2) Low water
 - 3) High water
 - 4) Water Supply Temperature
 - 5) Water Return Temperature
 - 6) Boiler Alarm
 - 7) Stack Temperature (fuel-fired only)
 - b. Write Properties:
 - 1) Leaving/Return Water Temperature Setpoint
 - 2) Boiler Enable
 - 3) Boiler Disable
4. Computer Room Unit Requirements
- a. Read Properties:
 - 1) Status
 - 2) General Alarm
 - 3) Filter Alarm
 - 4) Supply Air Temperature (SAT)
 - 5) Return Air Temperature (RAT)
 - 6) Relative Humidity
 - b. Write Properties:
 - 1) Start/Stop
 - 2) Temp Setpoint
 - 3) Humidify Setpoint
 - 4) De-Humidify Setpoint
5. Variable Frequency Drive Requirements
- a. Read Properties:
 - 1) Frequency
 - 2) Power
 - 3) Motor Current
 - 4) Runtime
 - 5) Fault Alarm
 - b. Write Properties:
 - 1) Start
 - 2) Stop
 - 3) Frequency Setpoint
 - 4) Minimum Frequency
 - 5) Maximum Frequency
 - 6) Ramp Time
 - 7) Max Current
 - 8) Max Torque
6. Generator Requirements
- a. Read Properties:
 - 1) Run Time
 - 2) Engine Temperature

- 3) Coolant Level
 - 4) Oil Pressure
 - 5) No AC Output Alarm
 - 6) Battery Voltmeter
 - 7) Water Temperature
 - 8) Ammeter
 - 9) Voltmeter
 - 10) Frequency
 - 11) Overcrank Alarm
 - 12) Overspeed Alarm
 - b. Write Properties:
 - 1) Start/Stop
7. Transfer Switch Requirements
 - a. Read Properties:
 - 1) Source 1 Power Available Status
 - 2) Source 2 Power Available Status
 - 3) Switch Position Status
 - b. Write Properties:
 - 1) N/A
8. Electrical Meter Requirements
 - a. Read Properties:
 - 1) KW*
 - 2) KW (demand)*
 - 3) KWH
 - 4) Amps*
 - 5) Volts*
 - 6) Neutral Amps*
 - 7) Power Factor*
 - 8) THD*
 - 9) KVA*
 - 10) KVAR*
 - 11) KVARHR
 - 12) Demand Reset
 - 13) Power Fail Alarm
 - 14) *Include Min/Max parameters
 - b. Write Properties:
 - 1) Demand Period
 - 2) Number of Demand Periods
 - 3) Reset KWH
 - 4) Reset KVARHR
 - 5) Reset Min/Max Values
9. Steam Metering Requirements
 - a. Read Properties:
 - 1) Flow Rate
 - 2) Flow Total

- 3) Temperature
 - 4) Pressure
 - 5) Peak Rate (time stamped)
 - 6) Alarm
 - b. Write Properties:
 - 1) Reset Flow Total
 - 2) Reset Min/Max Values
10. BTU Meter Requirements
- a. Read Properties:
 - 1) Water Flow Rate
 - 2) Water Supply Temperature
 - 3) Water Return Temperature
 - 4) BTU Rate
 - 5) BTU Total
 - b. Write Properties:
 - 1) Reset BTU Total

PART 4 - EXECUTION

4.1 GENERAL

- A. All products shall be installed in accordance with manufacturer's instructions. Installation of control components shall be performed by qualified control and instrumentation specialists. Only penetrations in the bottom of enclosures shall be made unless otherwise specified on contract drawings.

4.2 AC POWER WIRING

- A. The Contractor shall install 120 Volt AC power wiring for control system instrumentation if required by device. Power supplied to the device must be provided from the nearest available 120 Volt AC electrical panel. The breaker must be dedicated to the device and labeled. All work shall be performed in accordance with applicable sections of Division 16, "Electrical," unless otherwise specified. Contact the COTR before performing any electrical panel modification.
- B. Uninterruptible Power Source (UPS) input voltage shall be supplied by dedicated 120 volt AC duplex receptacle.
- C. 120 volt AC input power wiring for field panels shall be of sufficient length to allow connection to either UPS output receptacle or 120 volt AC duplex receptacle dedicated for UPS input.

4.3 EQUIPMENT ACCESSIBILITY

- A. Enclosures: Enclosures shall be installed in accordance with the National Electrical Code as a minimum standard. Doors shall not be obstructed and shall open a minimum of 90 degrees from its closed position.
- B. Instrumentation: All control system instrumentation shall be installed such that each device is accessible and unobstructed to facilitate ease of maintenance. Examples of obstructed equipment typically include piping surrounding valve actuators and covers that protect electronic components in VAV applications.
- C. Shelf for Uninterruptible Power Sources (UPS) shall be constructed of corrosion-resistant metal of sufficient gauge to support UPS weight without flexing with a 3/8-inch minimum lip around edge. Shelf shall be mounted beneath field panel and 6 inches minimum above finished floor.

4.4 VIBRATION ISOLATION

- A. Controllers and other devices sensitive to vibration shall be isolated by location or utilizing shock absorbing mounting devices.

4.5 SEQUENCE OF OPERATION

- A. The sequence of operation shall be as indicated on the design drawing(s).

4.6 CONTROL SYSTEM DRAWINGS

- A. At completion of the job, the Contractor shall furnish copies of as-built wiring diagrams, system schematics, and sequences of control. One (1) copy of each shall be enclosed in laminated plastic, suspended at each air handler and/or controlled system and inside each control panel, or as directed by the Contracting Officer's Technical Representative (COTR).
- B. Wiring diagrams shall show all instrumentation, interlocks and connection information required for controlling the mechanical equipment.

4.7 SYSTEM VERIFICATION AND STARTUP

- A. Verification testing shall be performed in the presence of the Government Construction Management Inspector and shall be repeated, as necessary, until each system or control loop is successfully verified.
- B. The Contractor shall have factory-authorized representatives perform system start-up and adjustment after acceptance of test plans.
- C. The Contractor shall demonstrate to the Government through a system verification test that final calibrations and adjustments are accurate and each control loop operates as defined by the sequence of operation. All deficiencies shall be corrected prior to final acceptance. The Government Construction Management Inspector shall witness all verification tests.
- D. The Controls Contractor shall perform a complete checkout and verification of the controls and instrumentation before total system commissioning begins. The Controls Contractor shall

participate in the total integrated system commissioning. Integrated system commissioning procedures are specified in Section 15995, "Commissioning of HVAC Systems."

END OF SECTION